Physics analysis activities at ALICE-CIAE group

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24-07-2025

China Institute of Atomic Energy

Overview

- W-boson production in Pb–Pb collisions
- Non-prompt D-meson production
- Anisotropic flow measurements

ALICE-CIAE team

- Team leader:
  - Xiaomei Li
- Deputy:
  - Mingrui Zhao
- Ph.D Students:
  - Shihai Jia, Zhiyong Lu, Shoulong Lin, Peiyu Li, Shangtai Jin
- Master Students:
  - Yongxi Du

W-boson production

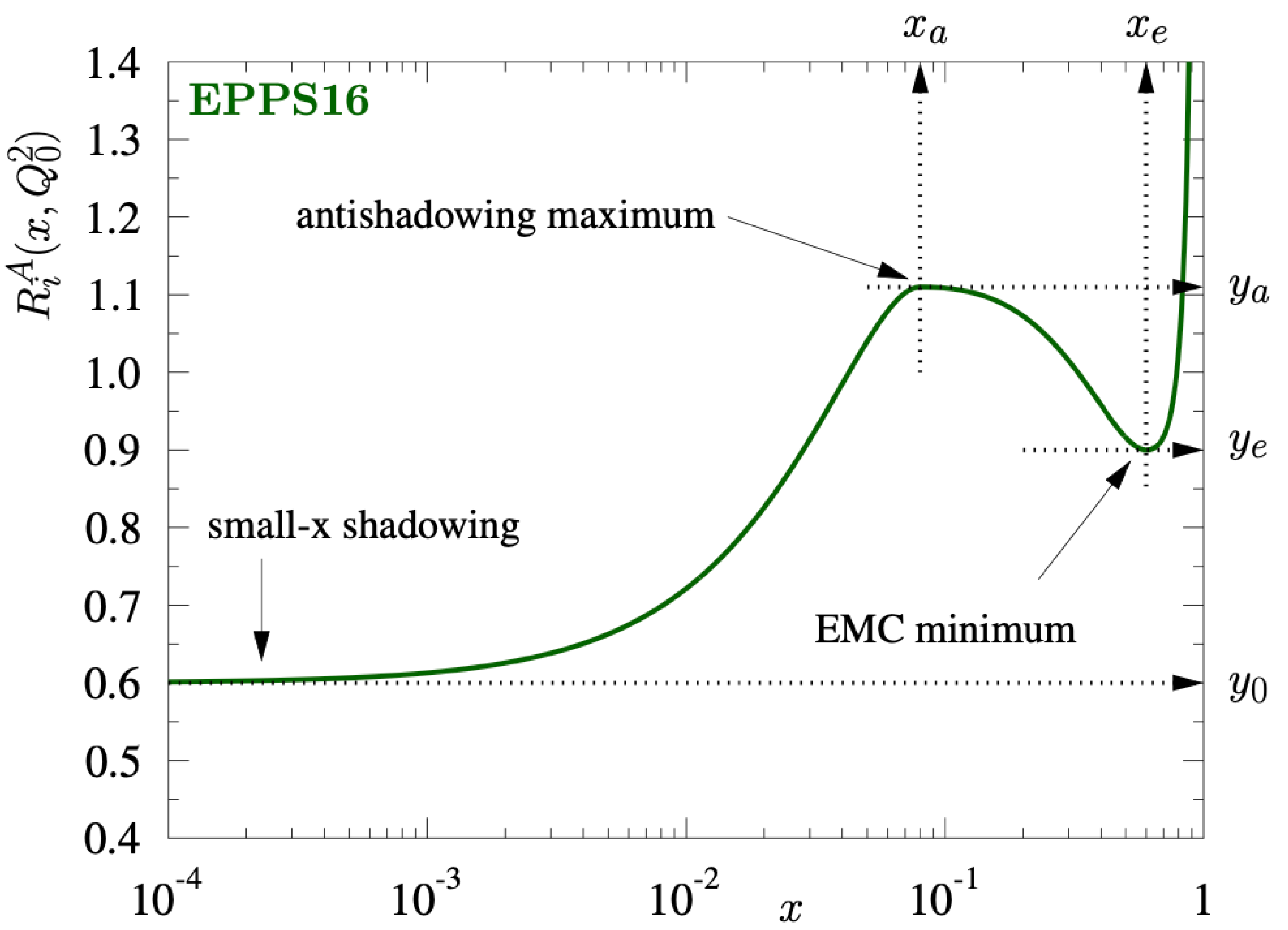
Mingrui Zhao (supervised by Xiaoming Zhang and Nicole Bastid)
Collaboration with:
Guillaume Taillepied, Nicole Bastid, Xavier Bernard Lopez
from Clermont-Ferrand University

W-boson production

[JHEP 05 (2023) 03]

First measurement of W production at LHC energy in PbPb at small-x

- W bosons: sensitive probes of the **nuclear modifications of the Partonic Distribution Functions**:
  - Production well described by perturbative QCD and electroweak theory
  - Produced in the **hard processes**, during the **initial stages** of the collision
  - If studied in their leptonic decay: **insensitive** to the strongly-interacting medium



W-boson production

[JHEP 05 (2023) 03]

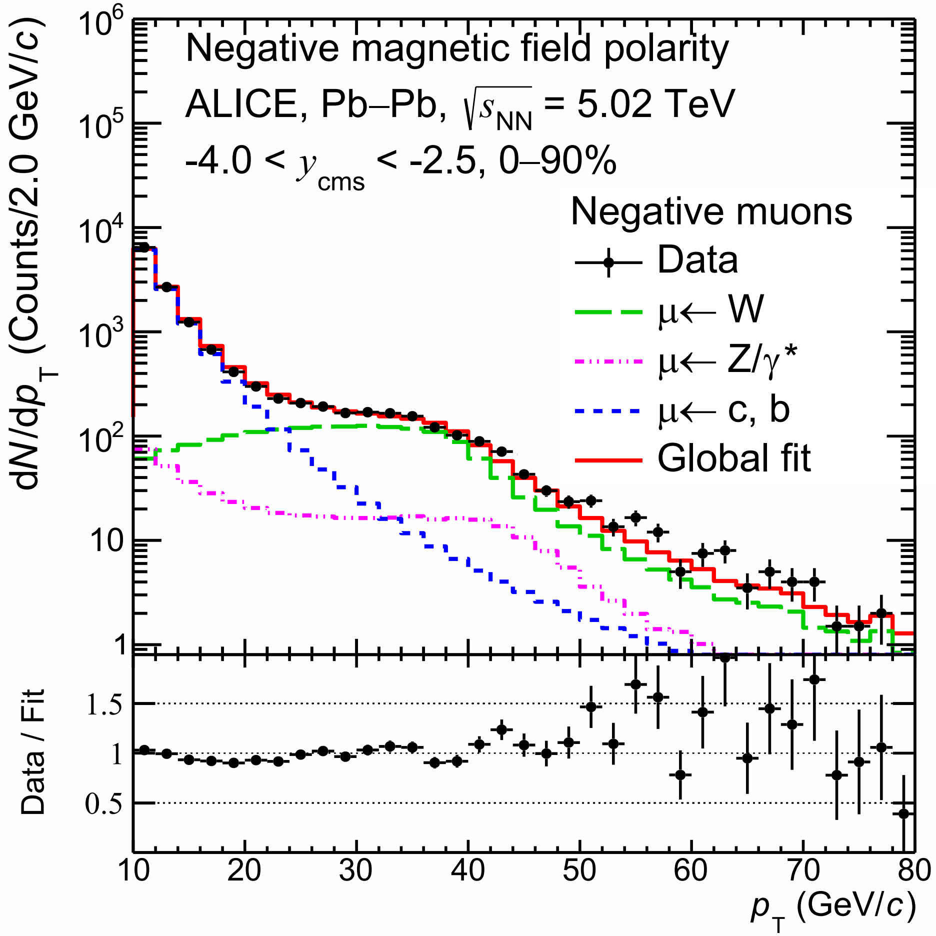
First measurement of W production at LHC energy in PbPb at small-x

- W extraction: Fit of the single muons p_T distribution:

$$f(p_T) = N_{HF} \cdot f_{HF}(p_T) + N_{\mu\leftarrow W} \cdot (f_{\mu\leftarrow W}(p_T) + R \cdot f_{\mu\leftarrow Z}(p_T))$$

- $f_X(p_T)$: MC templates (FONLL, POWHEG),
- N_X: free parameters,
- R: ratio of the Z to W cross sections from POWHEG

- Raw yield corrected for the acceptance × efficiency of the detector



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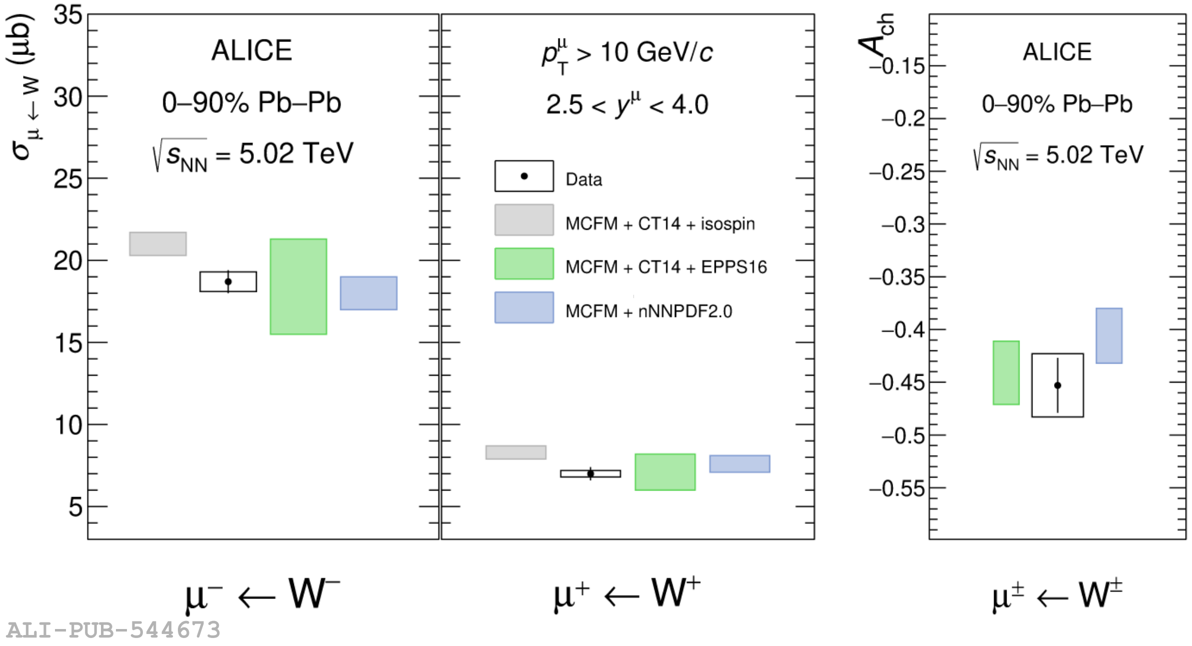
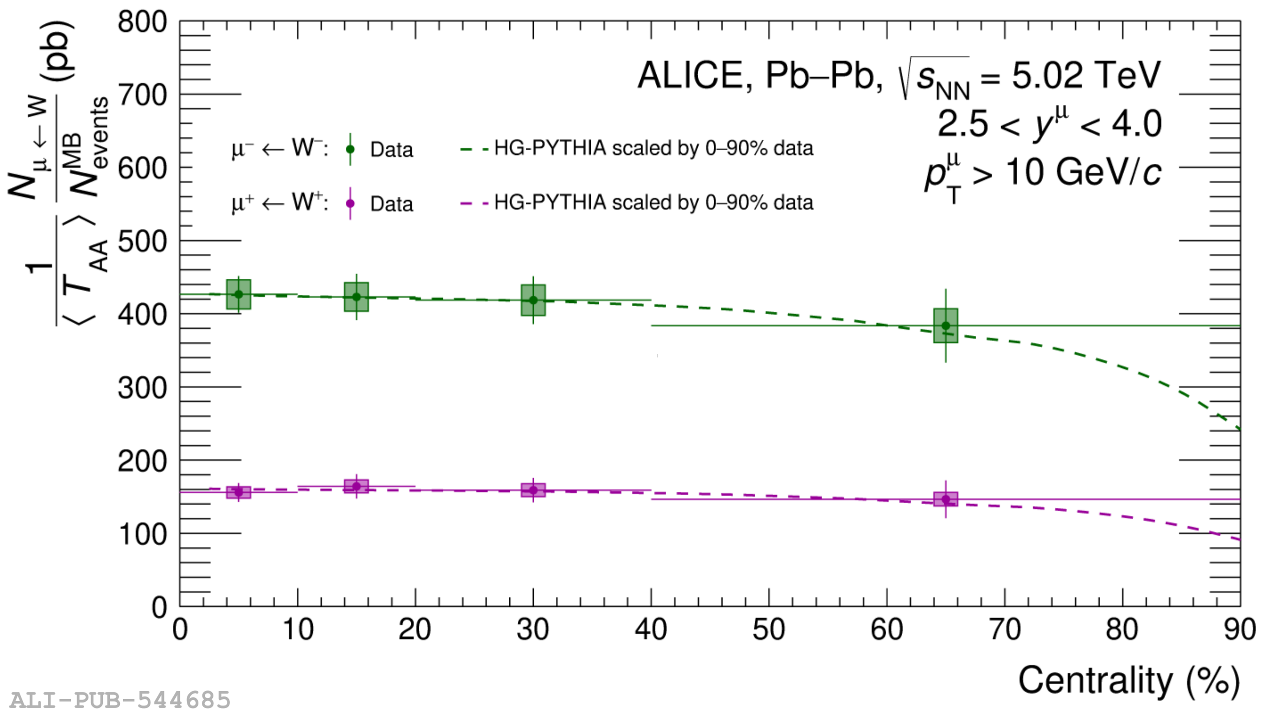
W-boson production

[JHEP 05 (2023) 03]

First measurement of W production at LHC energy in PbPb at small-x





- Models with **free-PDF overestimate** the cross section while models **including nuclear effects agree** with the measurement very well
- Suggests visible **nuclear effects**

- HG-PYTHIA: includes **biases from event selection** and geometry that cause suppression in peripheral collisions
- **Neutron-skin** effect affects the production of W^+ and W^- in **different directions**

Non-prompt D-meson production

Tao Jiang (supervised by Xinye Peng),
Collaboration with
Stefano Politano, Francesco Prino, Binti Sharma
From Turin University and University of Jammu

Non-prompt D-meson production

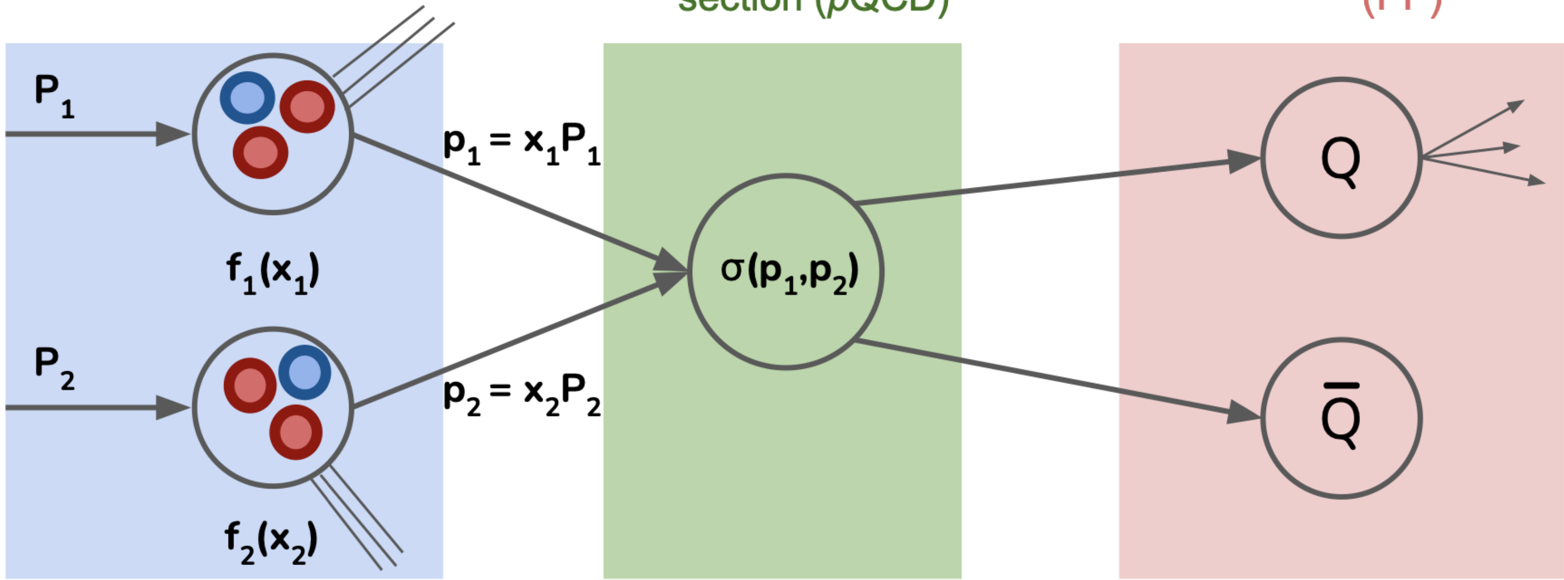
- Heavy-flavour production cross section in hadronic collisions: standard approach based on **factorisation theorem**
- Relative abundances and spectra of different hadron species sensitive to HF quark hadronization

$$\frac{d\sigma^{H_c}}{dp_T} = \mathrm{PDF}(x_1, \mu_F)\,\mathrm{PDF}(x_2, \mu_F) \otimes \frac{d\sigma^c}{dp_T^c}(x_1, x_2, \mu_R, \mu_F) \otimes D_{c\to H_c}(z = p_{H_c}/p_c, \mu_F)$$

Parton Distribution Functions

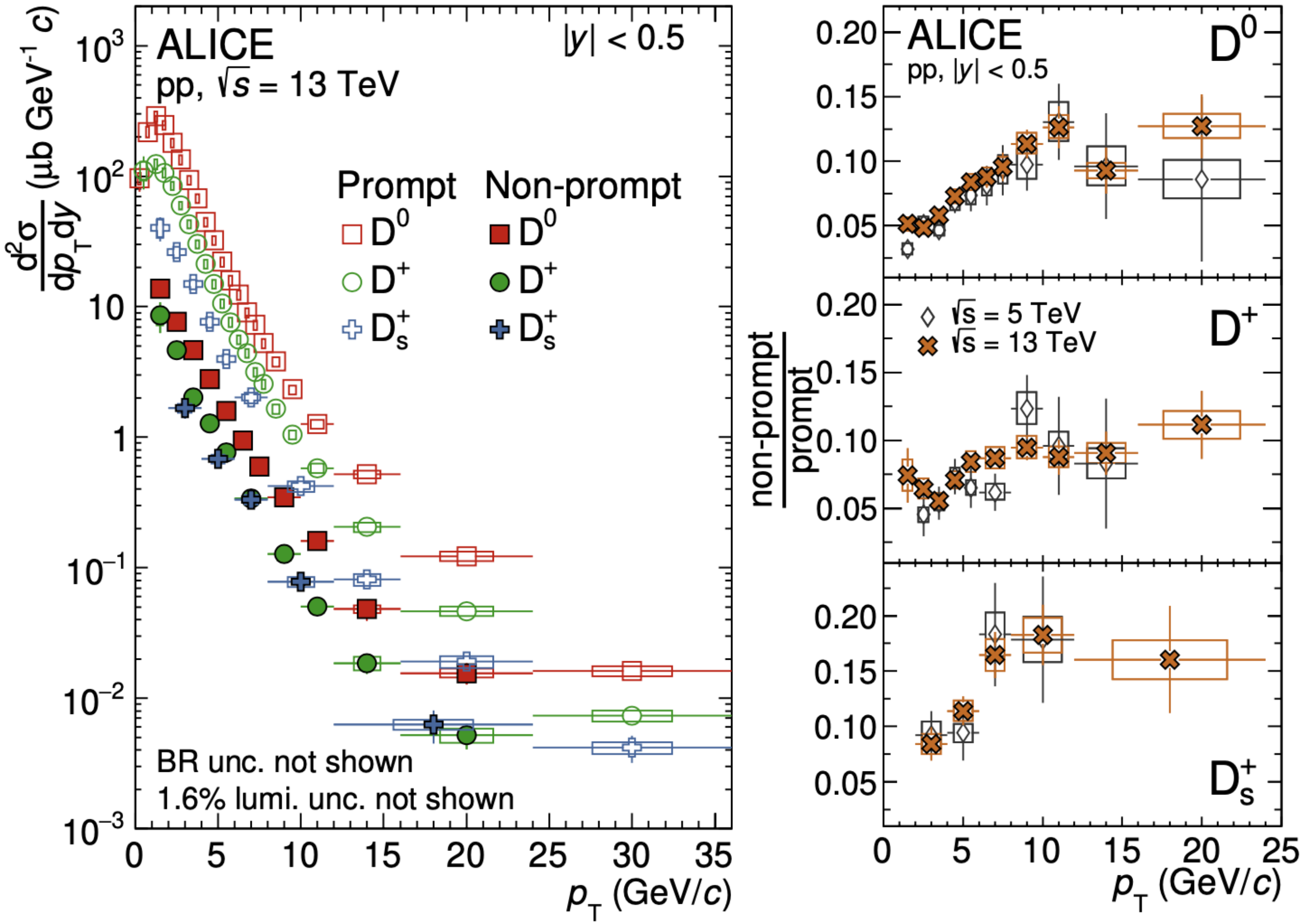
Hard scattering cross section (*p*QCD)

Fragmentation Function (FF)



Non-prompt D-meson production

[JHEP10 (2024) 110]

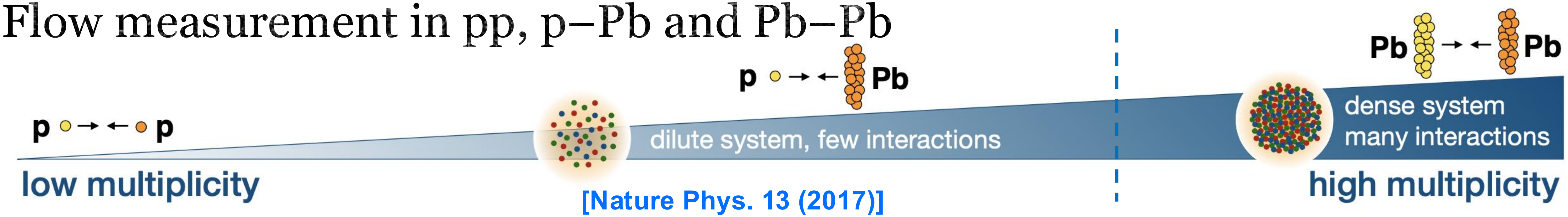


- Measured the transverse momentum differential production cross sections of non-prompt D mesons in pp collisions, covering D^0, D^+, and D_s^+ mesons.
- Achieved the **first measurements** of D^+ and D_s^+ mesons at this energy, with **improved p_T** resolution for D^0 mesons.

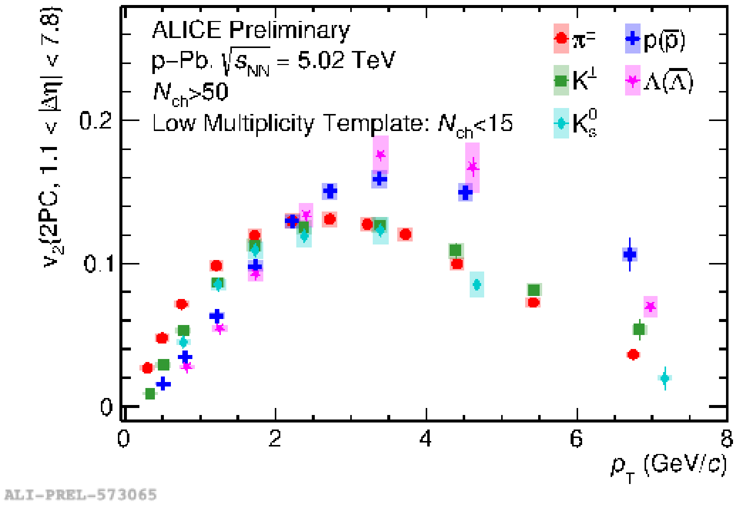
Flow measurement in pp, p–Pb, Xe–Xe, Pb–Pb

Mingrui Zhao, Zhiyong Lu (supervised by You Zhou)
From Copenhagen University

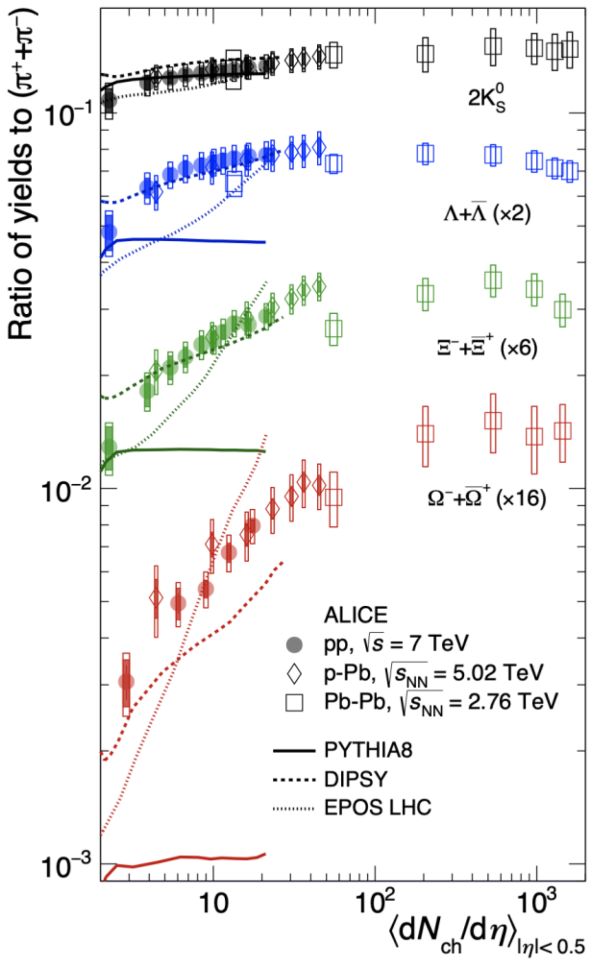
Flow measurement in pp, p–Pb and Pb–Pb



[Nature Phys. 13 (2017)]



PID Flow

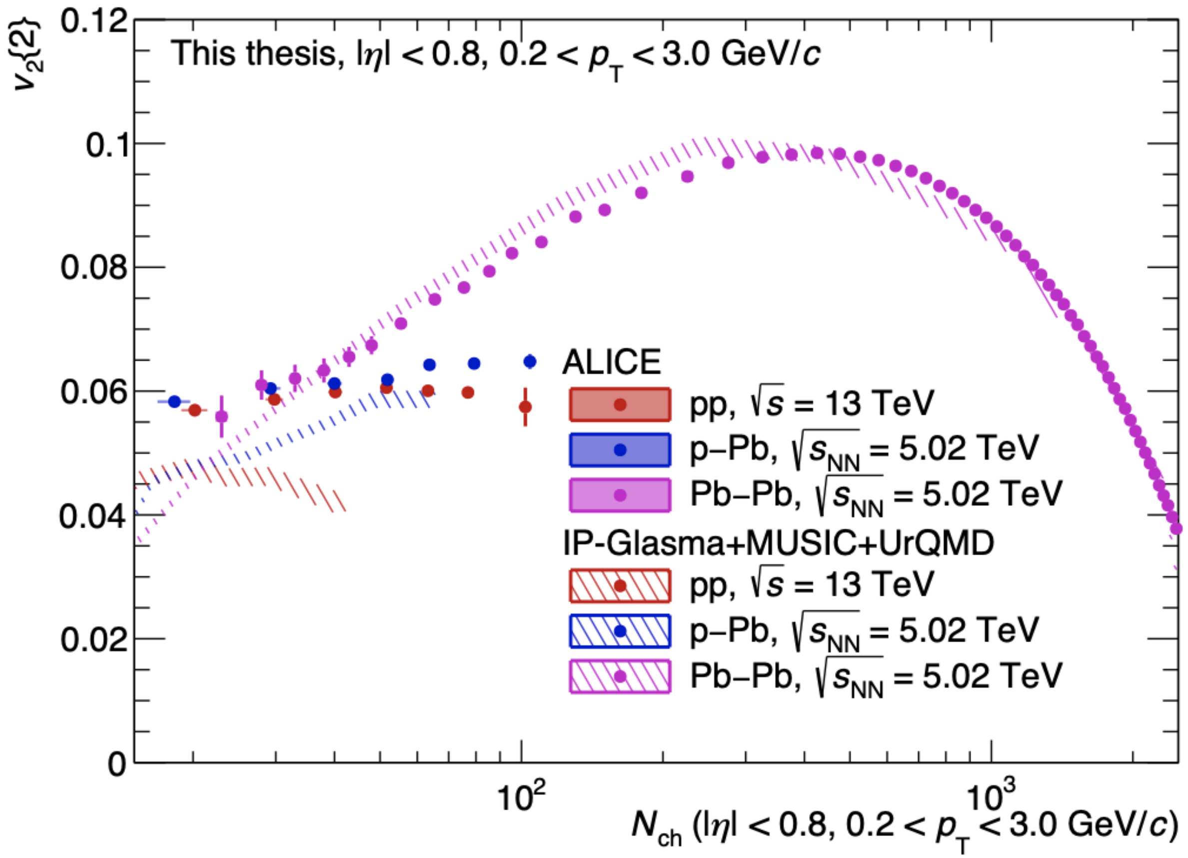


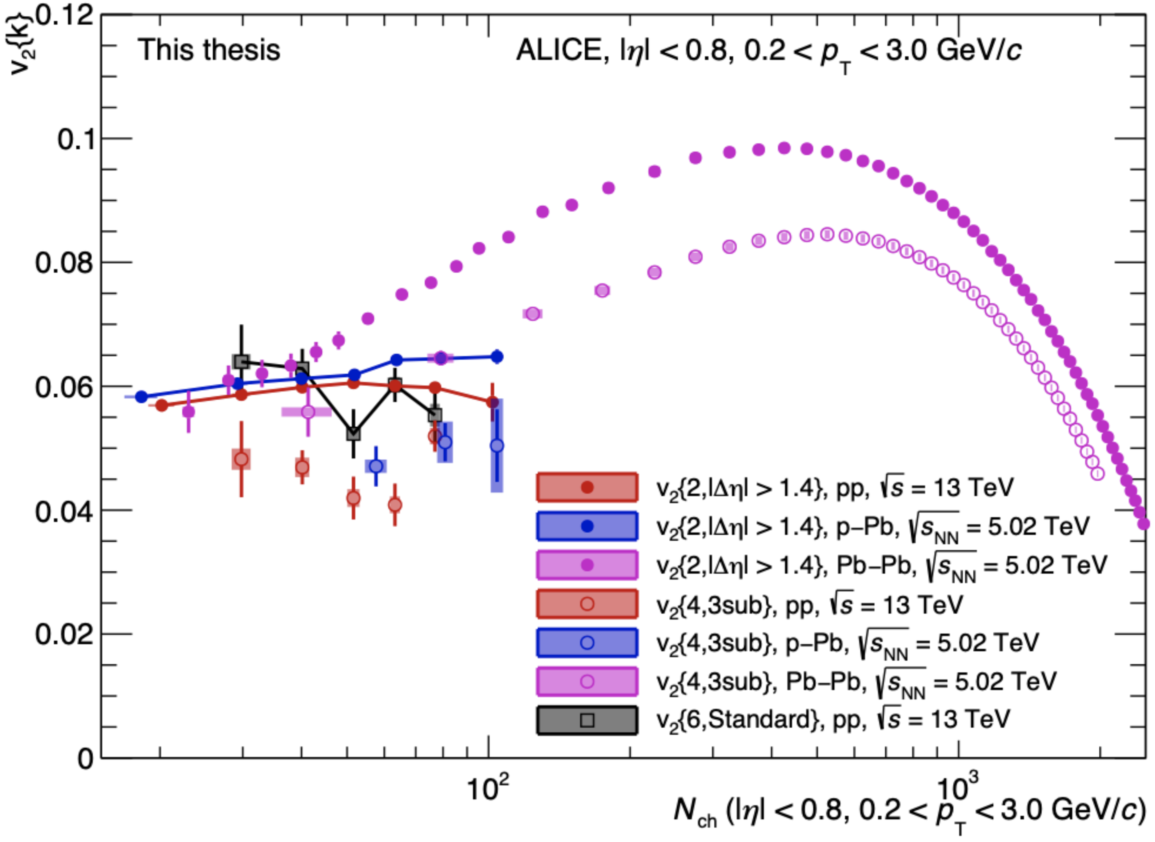
Strangeness enhancement

Discovery of the last decade:
QGP is found almost **everywhere** from large system (PbPb) to small system (pp, pPb)

Flow measurement in pp, p–Pb and Pb–Pb

[CERN-THESIS-2024-208][QM22]



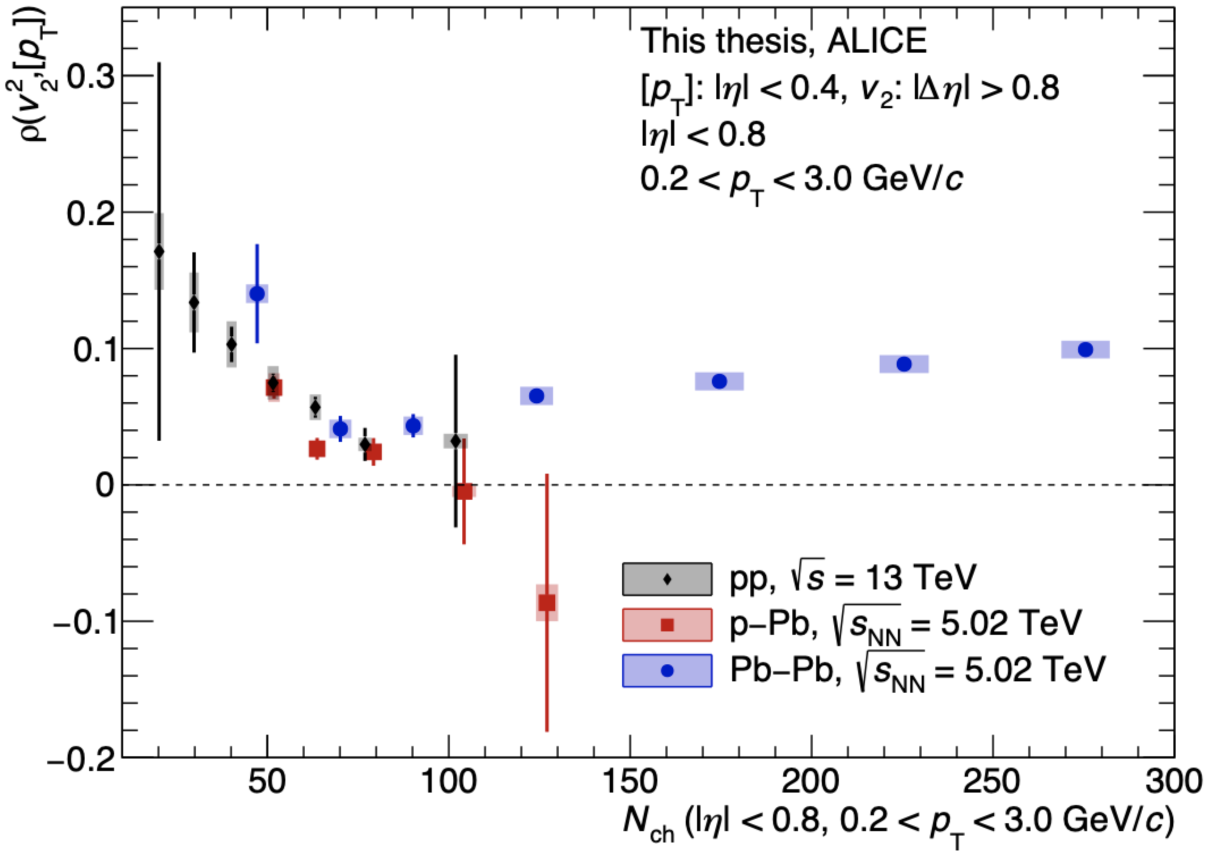


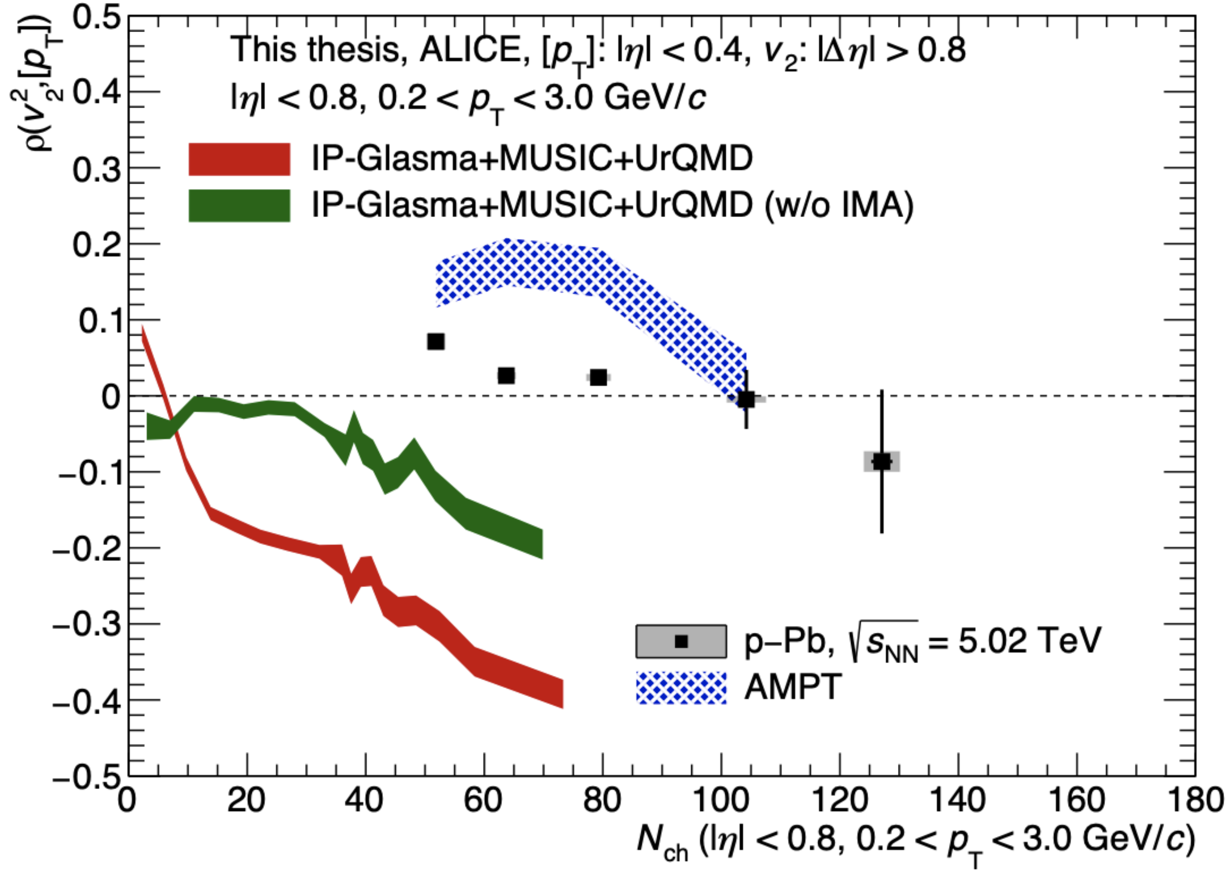
- Measured the $v_n\{2\}$ and $c_2\{m\}$ (with the **multi-particle cumulants (Q-cumulants)** method) in pp, pPb and PbPb collisions
- Performed detailed correction including efficiency/non-uniform acceptance etc.
- Provides constrain on models

Flow-mean p_T correlations

[CERN-THESIS-2024-208][QM23]

First measurements in small system at low p_T



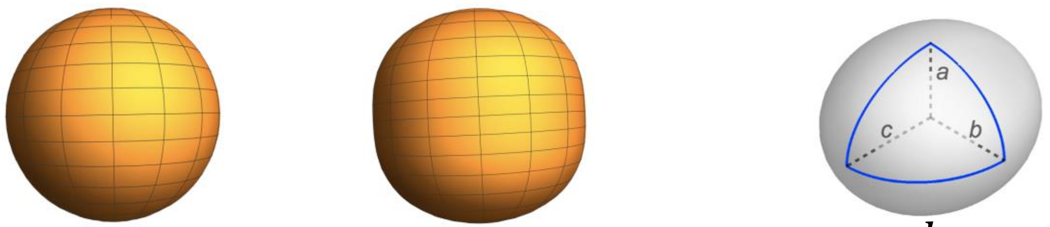


- Initial **size-shape** correlation, sensitive to **CGC effects**
- Models fails to describe the data (with and without initial momentum anisotropy (IMA)) from CGC

Flow in Xe–Xe collisions

[arXiv:2409.04343, under PLB review]

$\beta_2 = 0 \quad \gamma = 0°$ $\beta_2 = 0.4 \quad \gamma = 0°$ $\beta_2 = 0.2 \quad \gamma = 30°$



$a \neq b \neq c$

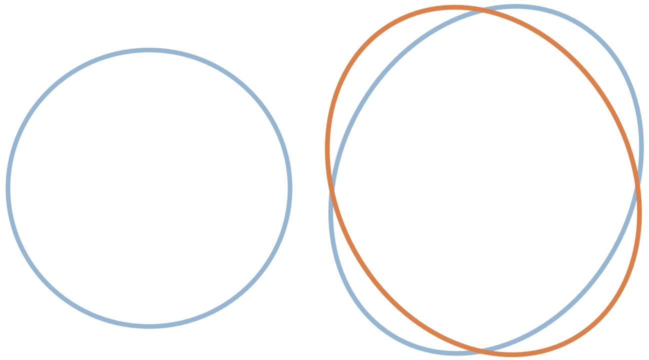
- Nucleon density described by Woods-Saxon profile

$$\rho(r,\theta,\phi) = \frac{\rho_0}{1 + e^{[r - R(\theta,\phi)]/a_0}}$$

$$R(\theta,\phi) = R_0(1 + \beta_2[\cos\gamma Y_{2,0} + \sin\gamma Y_{2,2}])$$

- β_2: overall quadrupole deformation
- γ: triaxial parameter

Central collision
(impact parameter $b \sim 0$)

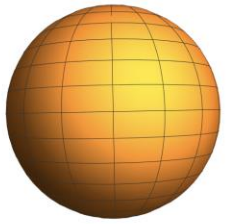


Flow in Xe–Xe collisions

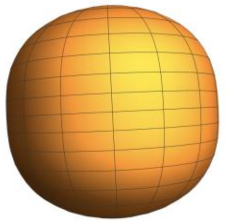
[arXiv:2409.04343, under PLB review]

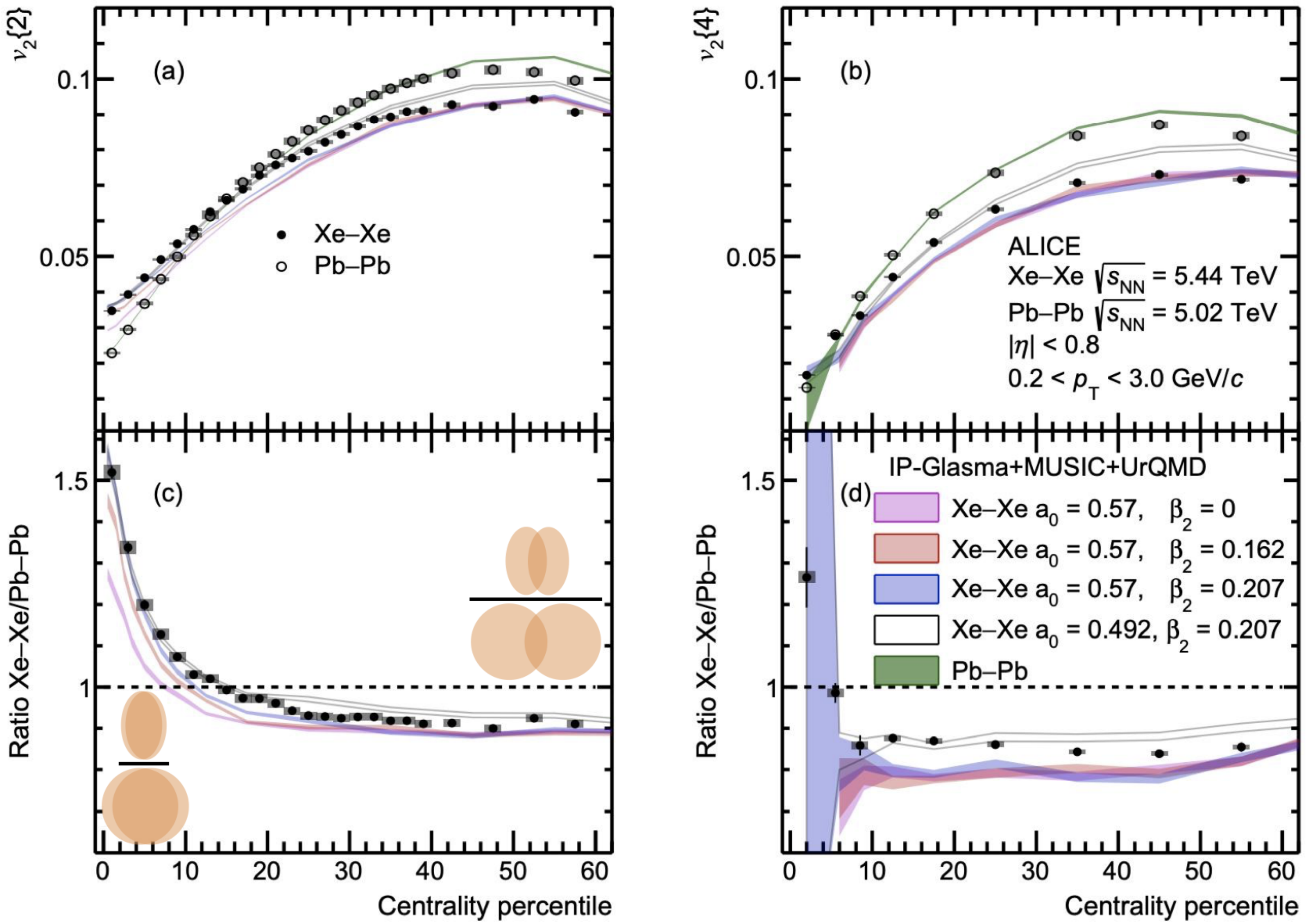
- $v_2\{2\}$(Xe-Xe/Pb-Pb) starts from 1.5 in the most central collisions, then goes near 0.9 in midcentral collisions
- **Central collision**: **deformation** effect dominates, provides powerful constrain on Xe deformation

$\beta_2 = 0$ $\gamma = 0°$



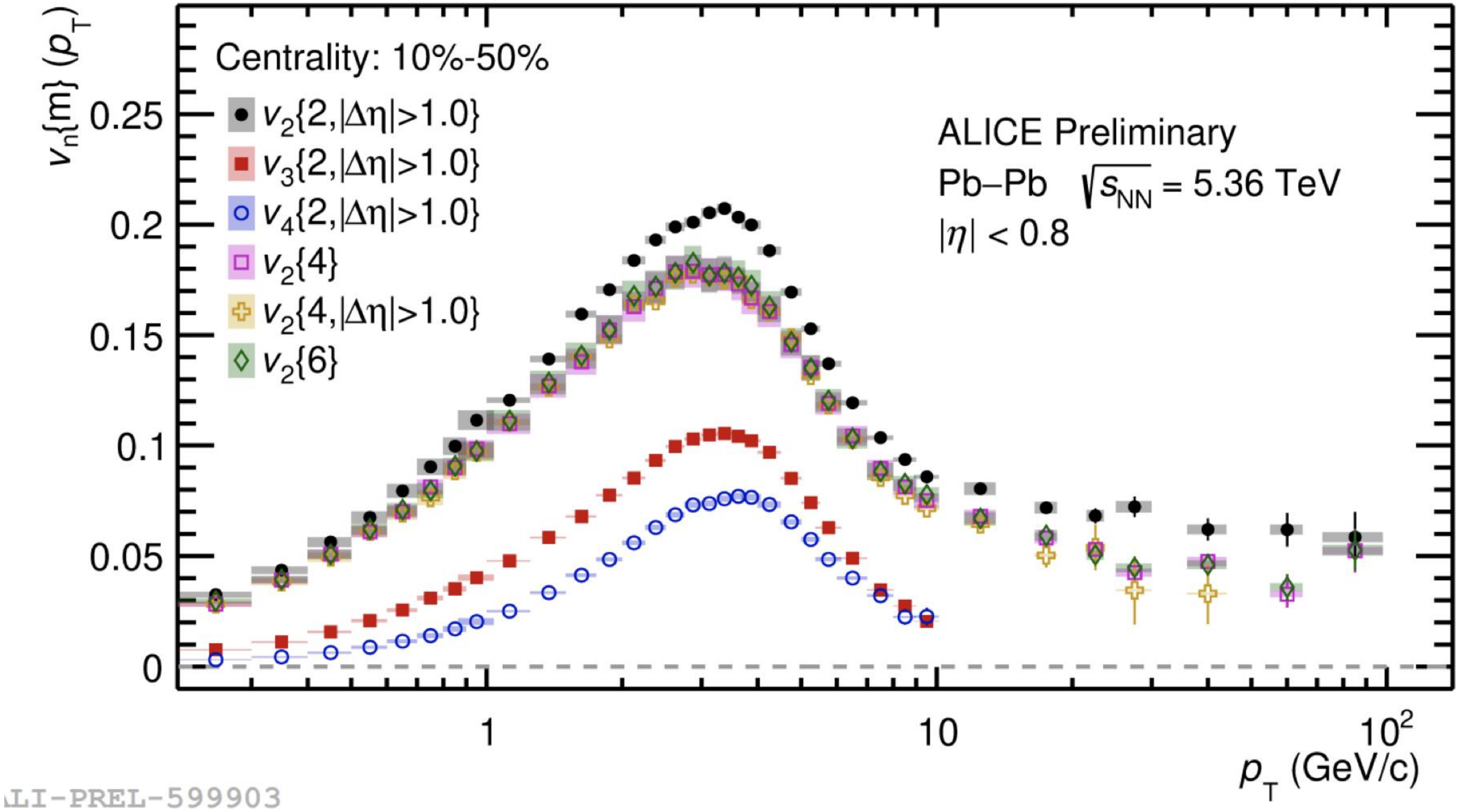
$\beta_2 = 0.4$ $\gamma = 0°$





Flow in Pb–Pb collisions at Run 3

[QM25]



- **First** flow results from Run 3.
- Resolved the **long-standing inconsistency** between Run 2 and Run 3.
- Demonstrated the power of ALICE in flow measurement.

Summary

- Active in Physics Analysis
  - Leading and contributing to key analyses over the past few years.
- Broad Physics Coverage
  - Working on multiple topics, ensuring diverse expertise.
- Strong Collaborations
  - Partnering with institutes and universities globally.
- Future Goals
  - Expanding research scope and strengthening collaborations.

Thank you for your attention